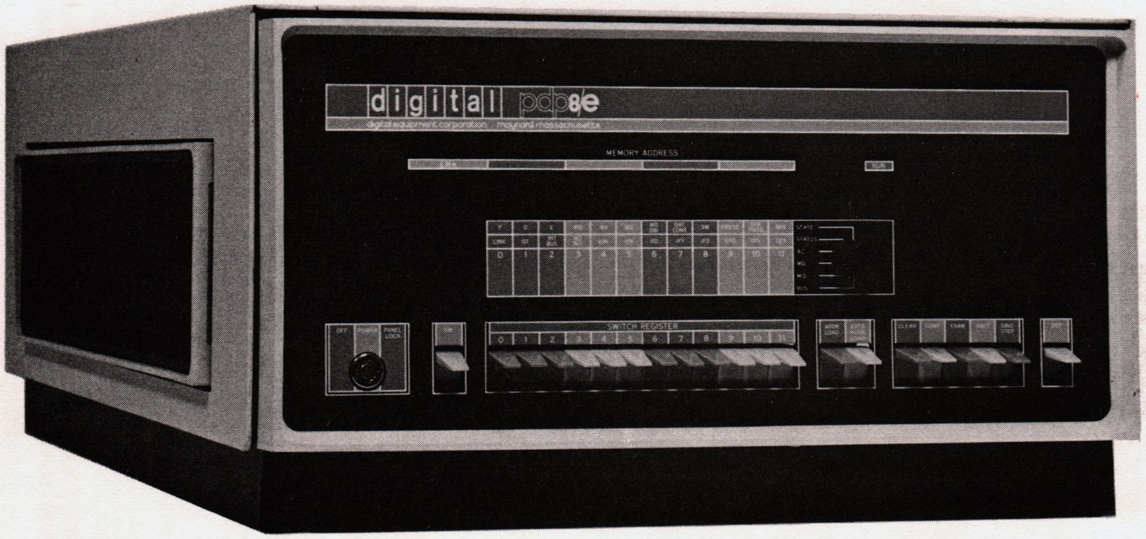
DIGITAL EQUIPMENT CORPORATION

education

EDUSYSTEMS and Calculators: A School Guide



computers are for kids — digital — EduSystems—expandable, economical

INTRODUCTION

For the school that is just beginning to build a computational resource center, the decision of what equipment to buy is never an easy one. Many schools find themselves wavering at the same point; shall we buy an Edusystem 10 or 20, or shall we buy a programmable calculator? This School Guide is a comparative paper, one which we hope will give your school some concrete facts to aid you in your upcoming decision.

This comparison of Edusystems 10 and 20 and programmable calculators deals with those capabilities that extend beyond a pure calculating nature. To evaluate the two strictly in terms of functional capabilities would be an unfair comparison. Admittedly, programmable calculators are economical, accurate, and portable. Functionally, the calculator might be an attractive option for your school.

Why then choose a computer over a calculator? Because Edusystems offer vastly increased computational power, ease of use, applications, flexibility, and expandability, far overshadowing the advantages of calculators cited above. Perhaps most important is the fact that a computer is a tool to teach students how to think logically, not just to do arithmetic calculations. Vital educational value is derived from the logical thought process to break down a problem into sequential steps. With a computer, the emphasis shifts from results to procedure. Edusystems enhance this process because they are easy to use, and make it easy to write AND debug programs. Thus, the Edusystem is a TRANSPARENT tool for classroom problem solving, rather than the barrier to learning that a programmable calculator can so easily become.

The following pages examine those capabilities which a school must consider before buying anything. We ask you to examine all the facts before you make a final decision.

EASE OF USE

1) EduSystems 10 and 20 can be used the same day they are installed in the school.

2) EduSystem 10 is "simple like a calculator." It operates in immediate mode (or calculator mode) which allows calculations to be done independently of programming.

```
You type this:          PRINT 5/9*(98.6-32)
EduSystem 10 types:     37

You type this:          PRINT (-5+SQR(5↑2-4*2-12))/(2*2)
EduSystem 10 types:     1.5

You type this:          PRINT SQR(5↑2+7↑2)
EduSystem 10 types:     8.602325
```

3) EduSystems 10 and 20 have both simplicity and computer power. No need to trade-off as with programmable calculators, where the more complex the task, the more complex it is to understand and use.

4) EduSystems 10 and 20 are easy to operate; no need for a computer expert on the school staff.

5) Complete set of texts, instructional aids, and user's guides with EduSystems 10 and 20. These materials are written by educators for educators.

6) EduSystems 10 and 20 are easy for the school to use because they were designed specifically for the classroom.

PROGRAMMABILITY

1) Languages

a. Calculator "language" is not really a language.
b. Programmable calculators' "language" is based on the conventional non-programmable desk calculator. The calculator memory remembers the sequence in which keys are pressed.
c. Calculator "language" is adequate for simple tasks but the more complex the job, the more cryptic the language becomes.
d. EduSystems speak the universal language of BASIC.

e. BASIC is easy to learn; with as little as an hour of instruction, student can write meaningful programs.
f. BASIC IS ENGLISH and numbers, not complex computer language.
g. BASIC is versatile; handles increased complexity of tasks without becoming harder to use.
h. BASIC is programming oriented. There is a much smoother transition to more sophisticated problem solving.
i. Contemporary texts are using BASIC and teachers are teaching it.
j. BASIC is easier to use: note the programming comparison in Appendix A.

2) Documentation

a. Calculator programs cannot be documented--users must maintain an instruction sheet for data entry. If the sheet is lost, there is no "LIST" command (as in BASIC) for generating a new one.
b. BASIC programs can be commented, therefore are more easily understood by people other than the author.
c. BASIC programs need no description of program operation; calculators must have this.
d. EduSystems permit program storage at no extra cost with teletype paper tape reader/punch.
e. EduSystems offer 80 full columns of alphabetic textual output at no extra cost with the teletype.

3) Debugging

a. Debugging capability is particularly important in education environment. Few students will write perfect programs the first time.
b. Debugging is next to impossible on programmable calculators. A simple task such as inserting a command in a program is a difficult procedure.
c. To avoid calculator debugging problems, programmable units often are equipped with a library of ready-made programs. Users are urged to use them. The educational value of "programming" is reduced considerably if students do not write their own.
d. EduSystem debugging is simple. Entire statements may be inserted, deleted, or replaced with one keyboard command.
e. EduSystem 20 has an extended debugging feature, the EDIT command, which allows changes to be made to a portion of a BASIC statement without retyping the entire line of the code.

4) Program Output

a. Calculator output is in standard format (generally 10 to 15 columns of numbers, always right justified).
b. EduSystems 10 and 20 can print numbers and text in any layout specified by the user.
c. EduSystem 20 BASIC offers the "TAB" command for varied output formatting. Excellent for graphs, charts, and teletype plots.

5) Errors

a. No diagnostics for calculator errors. E.g., if dividing by zero on HP, a console light will be set. WANG has ability to program around it (if you think about it beforehand--otherwise, start over).
b. EduSystems BASIC has a complete set of error diagnostics, which are typed on the console terminal. Messages are in plain English. They will tell the user what the error is and where it occurred. For example:

```
SUBSCRIPT ERROR AT LINE 60
SYNTAX ERROR AT LINE 195
```

APPLICATIONS

1) Next to programmability, the major advantage of EduSystems are extensive, in-depth applications. Calculating is merely the start. This leads on to broader problem solving in math, science, and business studies.

2) For students who intend to go on to college, EduSystems 10 or 20 will give them experience using a contemporary machine, not a limited calculator. Knowledge acquired here can be transferred to other disciplines at the high school and college levels.

3) The universal language of BASIC is used in the college computing environment. Calculator language isn't. It is an easy step from BASIC to other computer languages like FORTRAN or ALGOL. Not so with "calculator-speak."

4) EduSystems 10 and 20 are problem solving tools. Great educational value is derived from the logical thought process required to break down a procedure into sequential steps. The emphasis shifts from results to procedure. EduSystems enhance this process because they are easy to use, and make it easy

to write AND debug programs. Thus, the computer is a TRANSPARENT tool for classroom problem solving, rather than a barrier to learning that a programmable calculator can so easily become.

5) The library of EduSystem application programs was not designed as a substitute for programming and debugging. They are used as classroom aids, enhancements or extensions to the current curriculum. They are designed especially for the classroom, unlike the calculator programs. Many teachers generate their own application programs for classroom use. With calculators, that job isn't nearly so simple.

6) EduSystems run simulations; calculators don't. Today, it's vital to expose students to phenomena normally beyond their reach. There are a lot of things a teacher couldn't teach without Simulation Programs, e.g., landing a capsule on the moon (teaches Newton's 2nd law in a contemporary manner), managing the pollution level of a river, genetic reproduction, x-ray diffraction, chemical equilibrium, etc.

7) Applications cover mathematics, physical sciences, social sciences and business, with an option to incorporate computer science into the curriculum (impossible with calculators).

EXPANDABILITY

1) When schools need to grow beyond simple calculations (which they more than likely will), there is no place to expand with programmable calculators.

2) Expansion capabilities built into EduSystems avoid dead ends. If your school can foresee growth, you should look seriously at EduSystem 10 as a starting point for expansion to EduSystem 20 and beyond.

3) EduSystem 10 (the single "calculator") expands gracefully to EduSystem 20 (5 "calculators"), with an additional 4K of memory and 4 terminals, and then to EduSystem 20 (8 "calculators") with another 4K of memory and 3 more terminals.

COMPACTNESS AND DURABILITY

1) EduSystems are compact and portable.

2) EduSystem 10 can be stored on a cart and moved from class to class.

3) EduSystem 20 teletypes can be moved to any location with a phone available.

4) The PDP-8/E itself is no bigger than a suitcase.

5) EduSystems 10 and 20 are durable and reliable. They've been designed for use in busy school environments; members of the 8-family have been used in schools since 1965.

COST

1) For all the power that EduSystem 10 will bring to your school, it costs as little as $163/month. And the cost is easily justified in terms of the simplicity and versatility of BASIC, as well as the other features mentioned above. Remember that EduSystem 10 is more than a calculator. It is a full-scale computer.

2) The five-user EduSystem 20 costs as little as $76/month per terminal! (which is really only $3,648 per terminal for outright purchase of all of EduSystem 20.) Where else could your school get a programmable calculator that performs as well for that price?

APPENDIX A

PROGRAMMING COMPARISON

BASIC AND CALCULATOR LANGUAGE

PROBLEM:

ANNUAL INTEREST

This program calculates i that satisfies the equation

$$R = P \frac{i(1+i)^n}{(1+i)^n - 1}$$

for a given R, P, and n.

where R = monthly payment
P = principal amount
n = number of payments
i = monthly interest rate

The program uses i and calculates and displays an annual interest.

The solution is based on a Newton-Raphson iteration technique which converges to a point which satisfies the condition

$$\left| i_k - i_{k-1} \right| < 10^{-7}$$

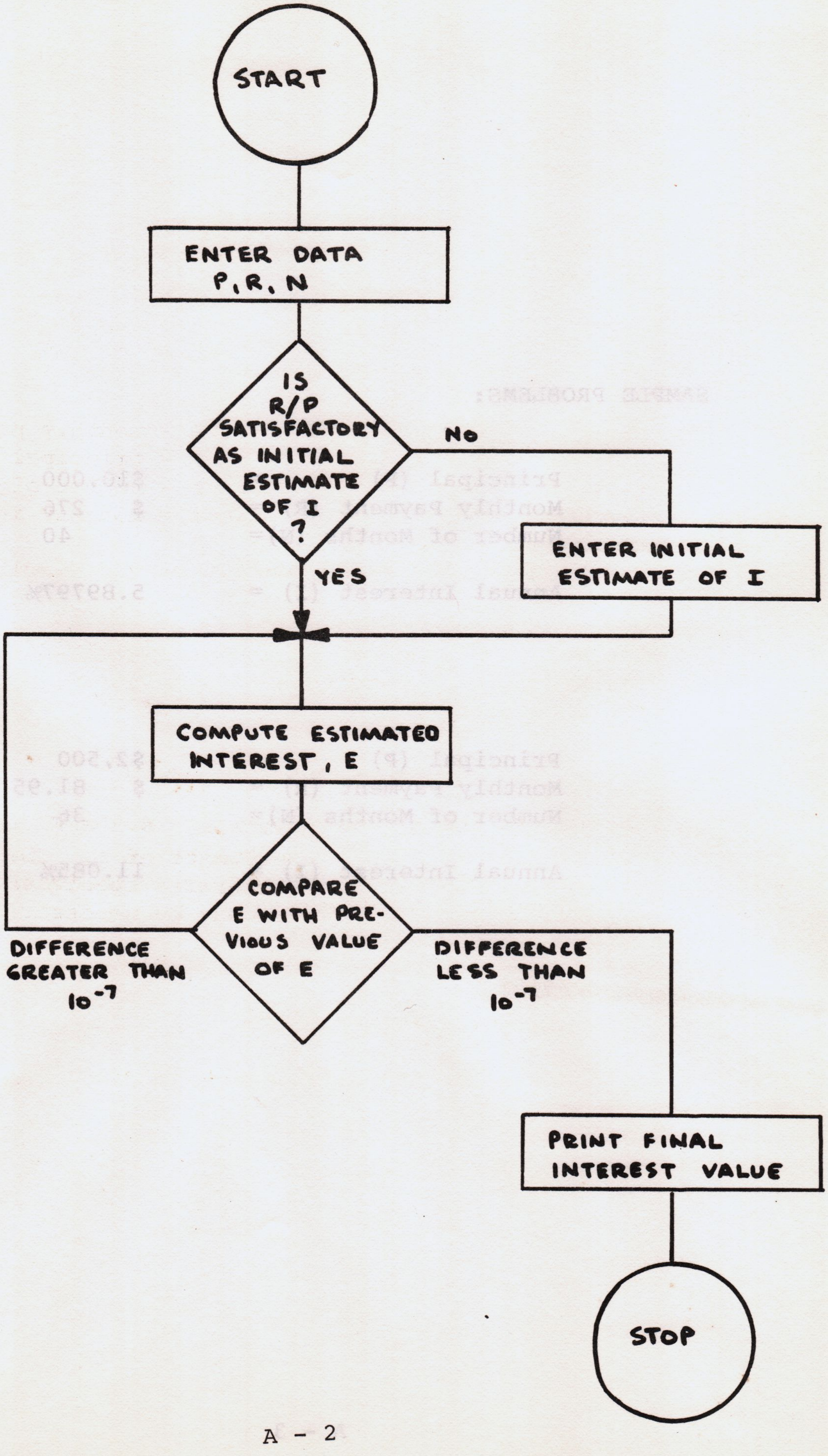
Note i_k is the K^{th} estimate of i and i_{k-1} is the $(K-1)^{th}$ estimate of i. The initial estimate of i is R/P unless otherwise specified. If the solution does not converge it may be necessary to enter a better initial estimate.

The value of i that satisfies the equation

$$f(i)=(1+i)^n(R-Pi)-R=0$$

is found. The annual interest is displayed.

FLOW CHART


START
ENTER DATA
P, R, N
IS
R/P
SATISFACTORY
AS INITIAL
ESTIMATE
OF I
?
NO
YES
ENTER INITIAL
ESTIMATE OF I
COMPUTE ESTIMATED
INTEREST, E
COMPARE
E WITH PRE-
VIOUS VALUE
OF E
DIFFERENCE
GREATER THAN
10^-7
DIFFERENCE
LESS THAN
10^-7
PRINT FINAL
INTEREST VALUE
STOP

SAMPLE PROBLEMS:

Principal (P) = $10,000
Monthly Payment (R) = $ 276
Number of Months (N)= 40

Annual Interest (I) = 5.89797%

Principal (P) = $2,500
Monthly Payment (R) = $ 81.95
Number of Months (N)= 36

Annual Interest (I) = 11.085%

BASIC PROGRAM EXAMPLE

```
10 PRINT "WHAT IS PRINCIPAL, MONTHLY PAYMENT, MONTHS";
15 INPUT P,R,N
20 E=R/P
25 PRINT "R/P=" E*1200 "(ANNUAL %)"
30 PRINT "SHALL I USE THIS AS INITIAL INTEREST ESTIMATE (Y OR N)";
35 INPUT A
40 IF A=Y GOTO 50
45 PRINT "EST INTR=";
47 INPUT E
50 PRINT
55 K=E
60 C=(K+1)↑N
65 Z=C*(N*(R-P*K)/(K+1)-P)
67 G=C*(R-P*K)-R
70 E=K-G/Z
75 IF ABS(E-K)<1.0E-7 GOTO 90
80 PRINT "EST INTR=" E*1200
85 GOTO 55
90 PRINT "FINAL INTR=" E*1200 "(ANNUAL %)"
99 END
```

```
RUN

WHAT IS PRINCIPAL, MONTHLY PAYMENT, MONTHS?10000,276,40
R/P= 33.12 (ANNUAL %)
SHALL I USE THIS AS INITIAL INTEREST ESTIMATE (Y OR N)Y

EST INTR= 21.9737
EST INTR= 14.2881
EST INTR= 9.55489
EST INTR= 7.05453
EST INTR= 6.08146
EST INTR= 5.90391
EST INTR= 5.89698
FINAL INTR= 5.89797 (ANNUAL %)

READY

RUN

WHAT IS PRINCIPAL, MONTHLY PAYMENT, MONTHS?2500,81.95,36
R/P= 39.336 (ANNUAL %)
SHALL I USE THIS AS INITIAL INTEREST ESTIMATE (Y OR N)Y

EST INTR= 27.0188
EST INTR= 18.6727
EST INTR= 13.7986
EST INTR= 11.6278
EST INTR= 11.1151
EST INTR= 11.0858
FINAL INTR= 11.0849 (ANNUAL %)

READY
```

0	CLEAR	20	
	1	01	DISPLAY 1 TO INDICATE FIRST ENTRY
	STOP	41	N R P — ENTER N,R, AND P
	ACC +	60	BRANCH FOR i_{est} ENTRY
	ROLL ↑	22	
	$x \rightarrow ()$	23	
	d	17	
	IF FLAG	43	
	1	01	
	3	03	
	ROLL ↑	22	GENERATE $i_{est} = \frac{R}{P}$
	$x \rightleftarrows y$	30	
	÷	35	
	↓	25	
1	GO TO ( )( )	44	BRANCH TO ITERATION
	2	02	
	1	01	
	CLEAR x	37	
	↑	27	
	↑	27	
	2	02	DISPLAY 2 TO INDICATE SECOND ENTRY
	STOP	41	i_{est} 0 0 — ENTER i_{est} IN PERCENT
	↑	27	CONVERT ANNUAL INTEREST RATE IN PERCENT TO MONTHLY RATE.
	1	01	
	2	02	
	0	00	
	0	00	
	÷	35	
2	↓	25	
	$x \rightarrow ()$	23	
FROM 6-c	b	14	
	↑	27	CALCULATE AND STORE $(i_K + 1)^n$
	1	01	
	+	33	
	↓	25	
	↑	27	
	ln x	65	
	ROLL ↑	22	
	f	15	
	×	36	
	↓	25	

3	x→( )	23	
	c	16	
	1	01	CALCULATE $f'(i_K)=(1+i_K)^n\left(-\frac{n(R-Pi_K)}{1+i_K}-P\right)$
	x⇄y	30	
	÷	35	
	d	17	
	ROLL ↑	22	
	b	14	
	×	36	
	e	12	
	x⇄y	30	
	—	34	
	↓	25	
	×	36	
4	ROLL ↓	31	
	x⇄y	30	
	f	15	
	×	36	
	d	17	
	—	34	
	c	16	
	×	36	
	x⇄y	30	CALCULATE $f(i_K)$
	ROLL ↓	31	
	×	36	
	e	12	
	—	34	
	ROLL ↓	31	CALCULATE $\frac{f(i_K)}{f'(i_K)}$
5	x⇄y	30	
	÷	35	
	b	14	CALCULATE $i_{K+1}=i_K-\frac{f(i_K)}{f'(i_K)}=i_K-\Delta_K$
	x⇄y	30	
	—	34	
	x⇄y	30	CONVERT $_{K+1}$ TO ANNUAL PERCENTAGE FOR DISPLAY
	x→( )	23	
	b	14	
	↑	27	
	1	01	
	2	02	
	0	00	
	0	00	
	×	36	

6	CLEAR x	37	
	ROLL ↓	31	
	PAUSE	57	$\boxed{i_{K+1}\,\% \qquad \Delta_K \qquad 0}$ DISPLAY EACH ITERATION
	$\lvert y \rvert$	55	COMPARE $\lvert i_{K+1} - i_K \rvert$ TO 10^{-7} TOLERANCE. IF LESS THAN 10^{-7} BRANCH TO DISPLAY. IF GREATER THAN 10^{-7} CONTINUE ITERATION.
	ROLL ↑	22	
	ENTER EXP	26	
	0	00	
	9	11	
	CHG SIGN	32	
	ROLL ↑	22	
	IF $x > y$	53	
	2	02	
	2	02	
	CLEAR x	37	CLEAR AND POSITION i_{K+1}
7	$x \rightleftarrows y$	30	
	CLEAR x	37	
	ROLL ↑	22	
	END	46	$\boxed{i \qquad 0 \qquad 0}$ DISPLAY

EDUSYSTEMS

Expandable, Economical, Easy to Use

	Purchase	Monthly Lease	Monthly Maint.
EduSystem 10 One terminal computer/supercalculator complete with BASIC and FOCAL software, textbooks, and learning aids	$ 7,390	$ 163	$ 87
EduSystem 20 Multi-user BASIC timesharing system complete with BASIC and FOCAL software, textbooks, and learning aids			
4 - user system	$15,540	342	212
8 - user system	25,240	556	372
EduSystem 30 Fast batch BASIC system with disk (or DECtape) and optical mark card reader	19,690	434	170
EduSystem 40 Combined EduSystem 20 and 30	29,640	653	330
EduSystem 50 Complete 16-user resource sharing multi-language, time-sharing system. BASIC, FOCAL, FORTRAN, ALGOL, PAL, all simultaneous	85,070	1,872	872

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